Validation and interpretation of OMI tropospheric NO_2 observations during INTEX-B

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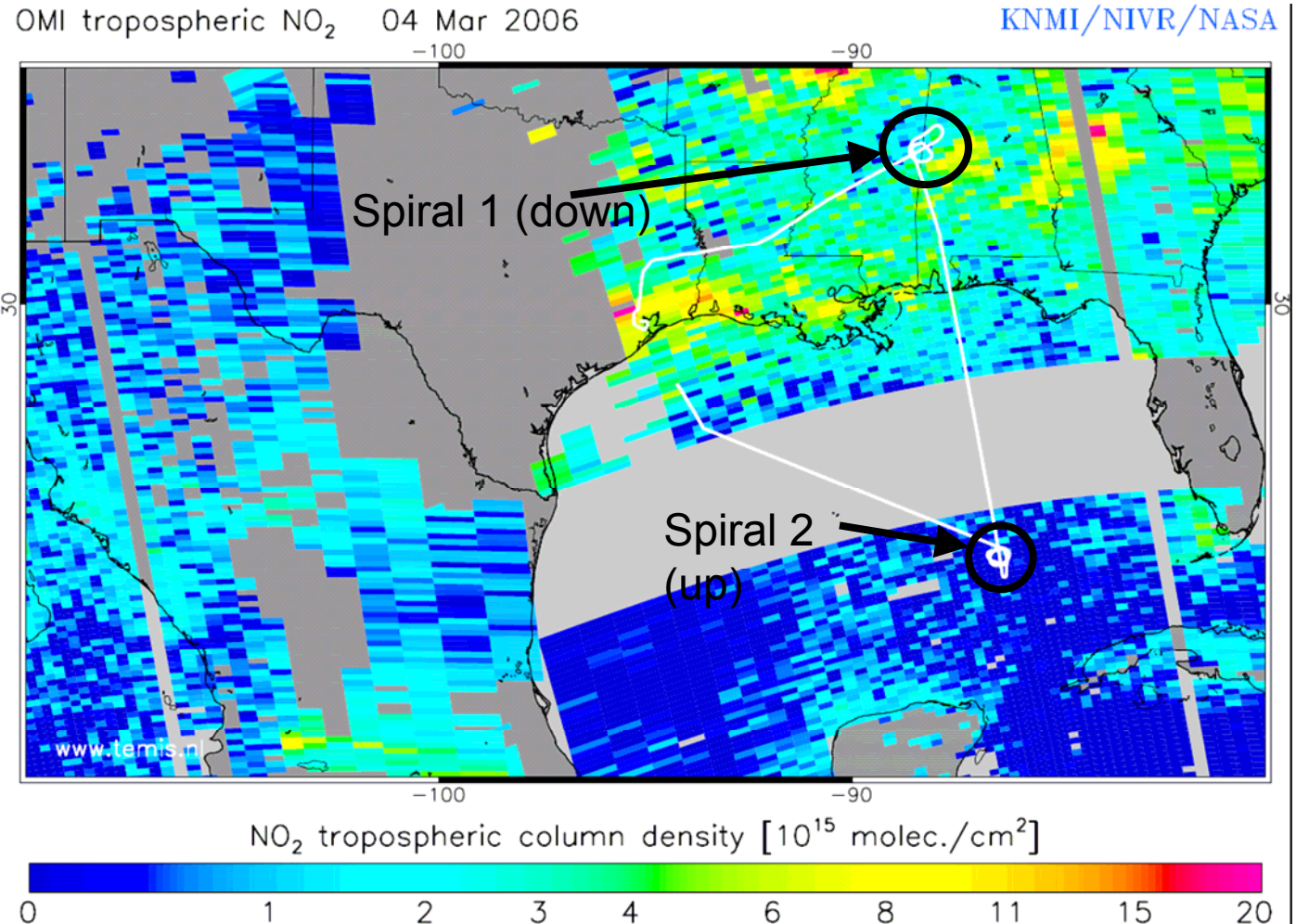
Important goal INTEX-B: EOS-Aura Validation

- Integration of aircraft and satellite observations
- a.o. sub-satellite spirals for validation OMI trace gases



Criteria

Cloud fraction < 20%

Use all OMI pixels covered by spatial extent spiral

Use of KNMI analysed near-real time product (www.temis.nl)

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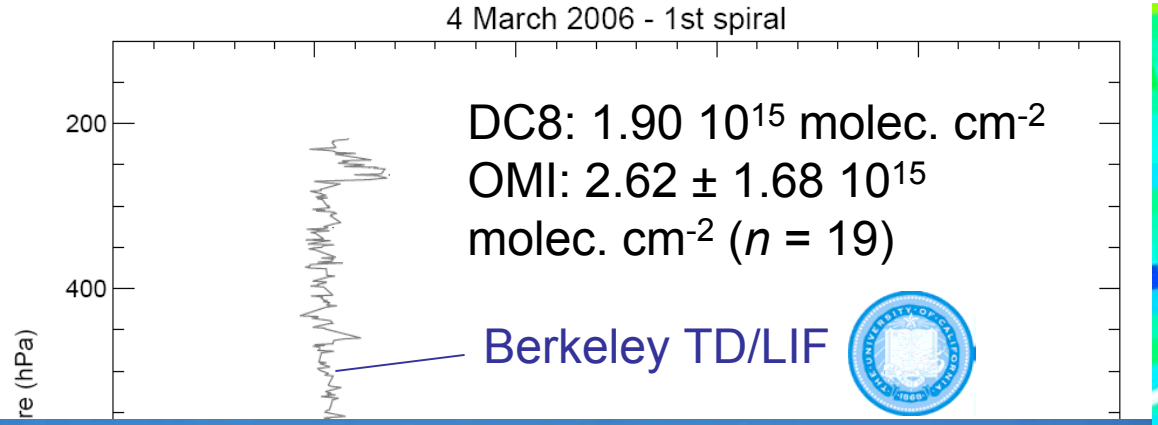
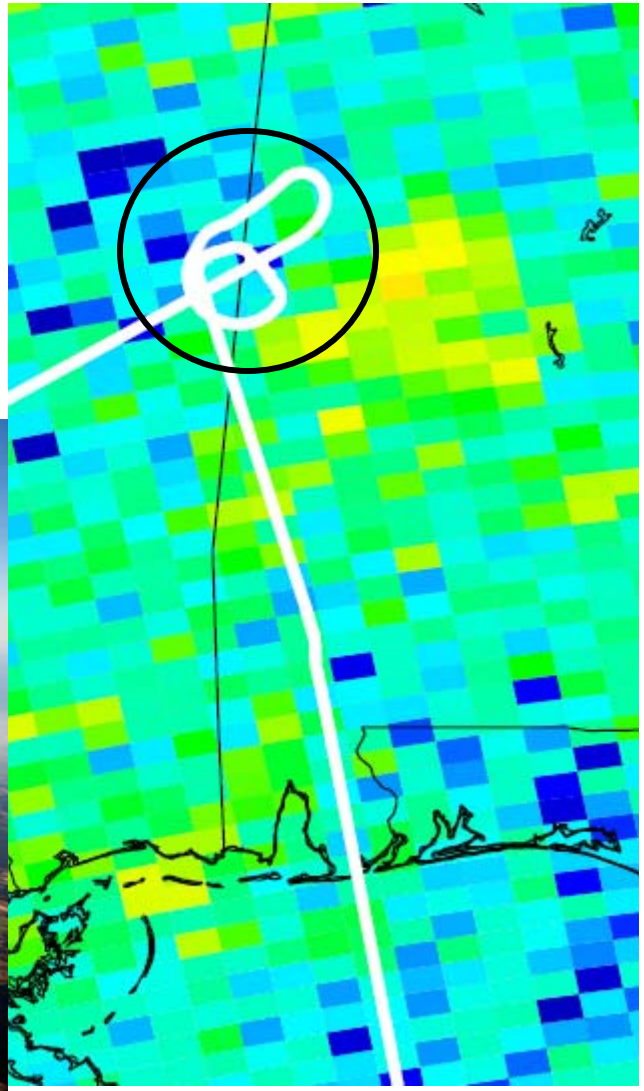
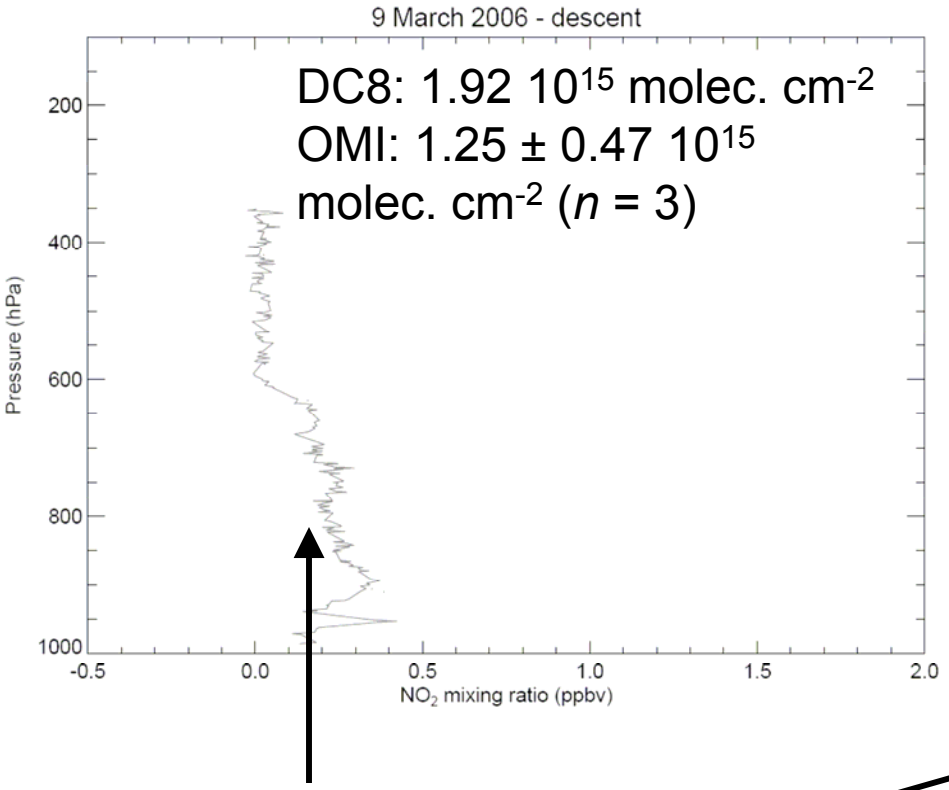
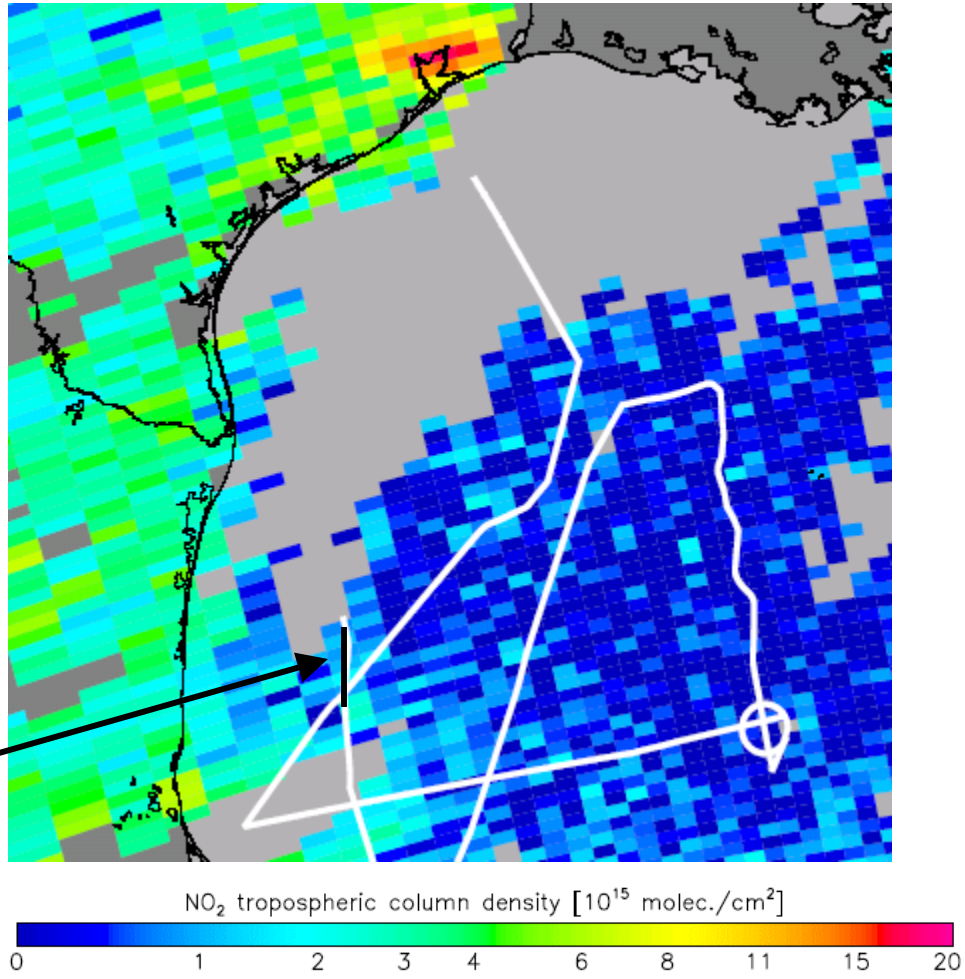
Validation of OMI tropospheric NO_2: 4 March 2006





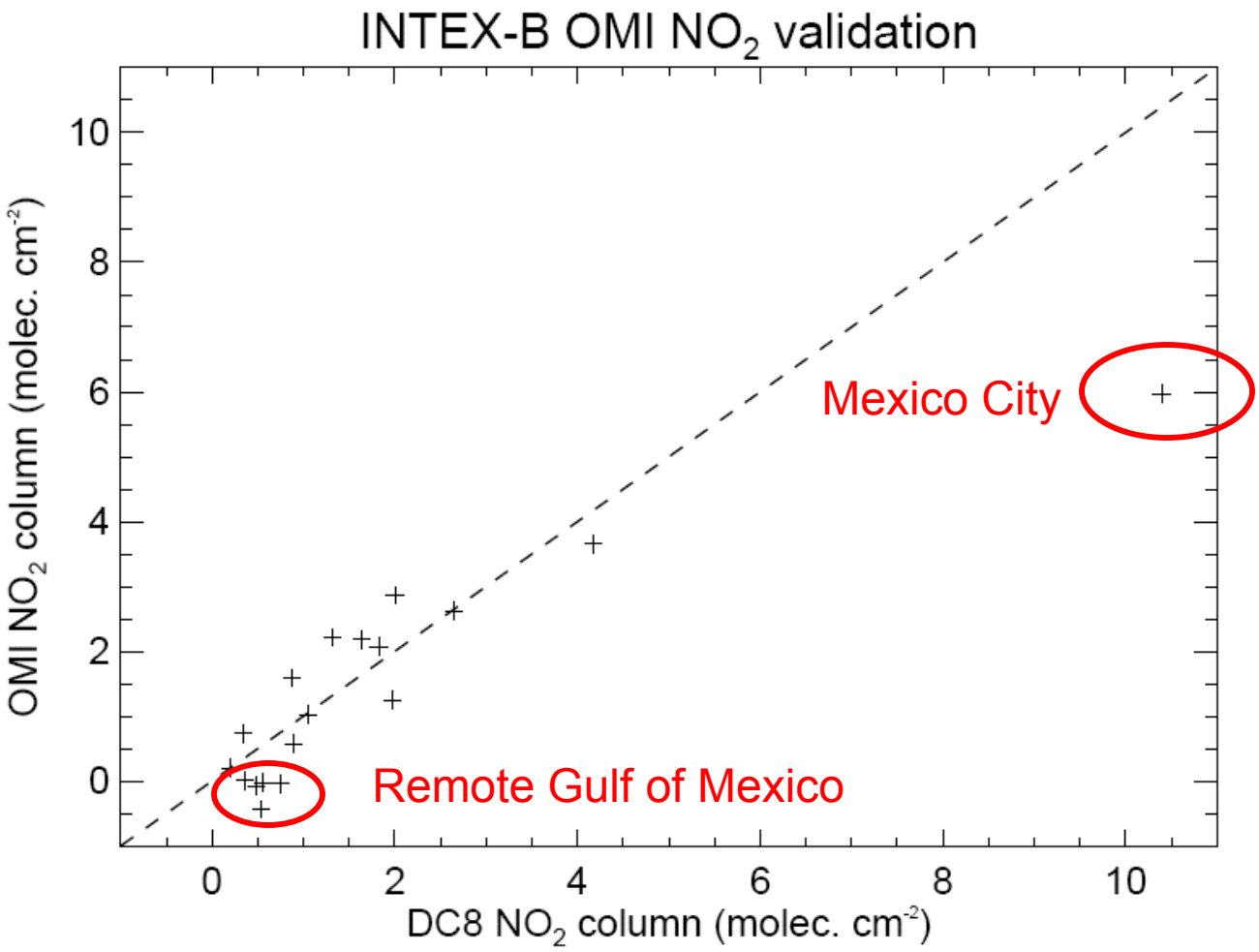
Validation of OMI tropospheric NO_2: 9 March 2006





OMI and DC8 seem to capture outflow of pollution along the Mexican East coast

All spiral flights during March 2006



All spirals

r = 0.89

n = 18

DC8-OMI: +0.31 10^{15} molec. cm^{-2}

RMS: 1.18 10^{15} molec. cm^{-2}

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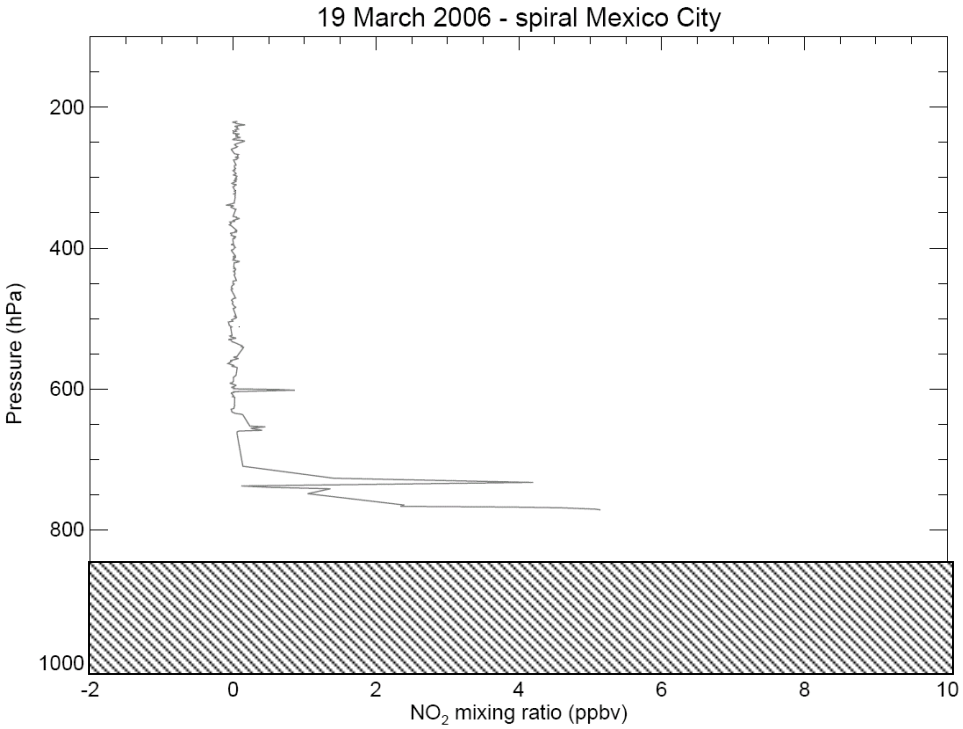
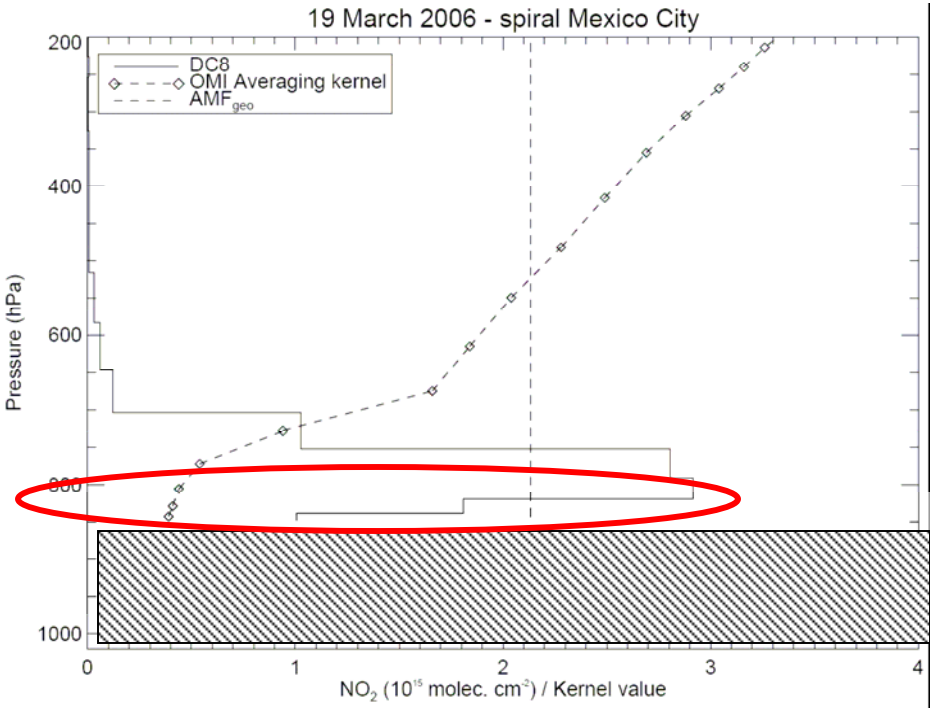
Mexico City outlier



Standard procedure: extrapolate to OMI surface level.



Lowest DC8 pressure: 772 hPa

Average p_{surf} (OMI): 853 hPa

On average extrapolated fraction: 13%

Outlier extrapolated fraction: 78%

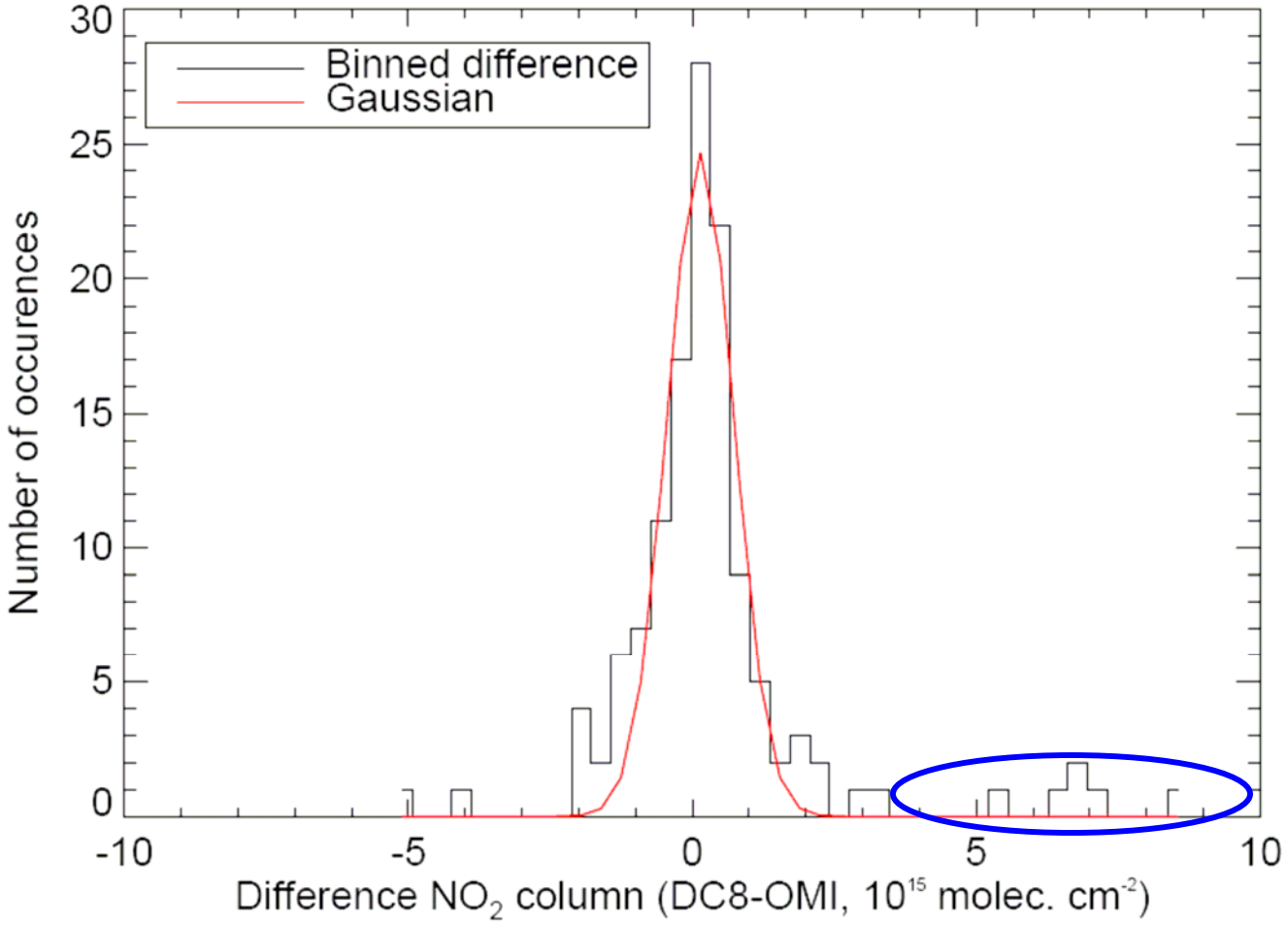
Statistical analysis

Take differences of individual OMI pixels with matching DC8 columns

128 OMI pixels

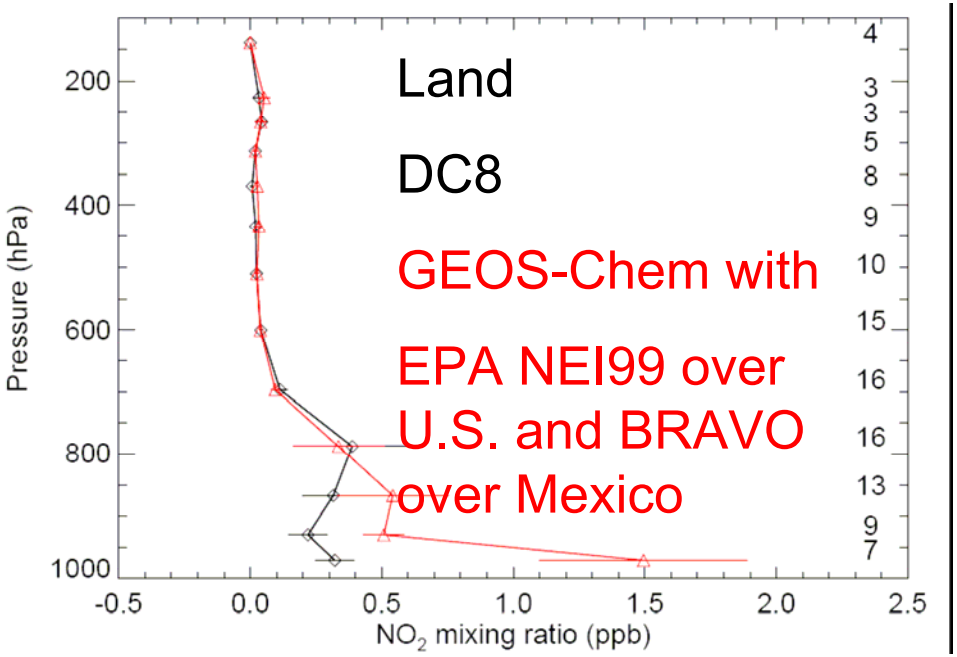
Center Gaussian = +0.16 molec. cm^{-2}

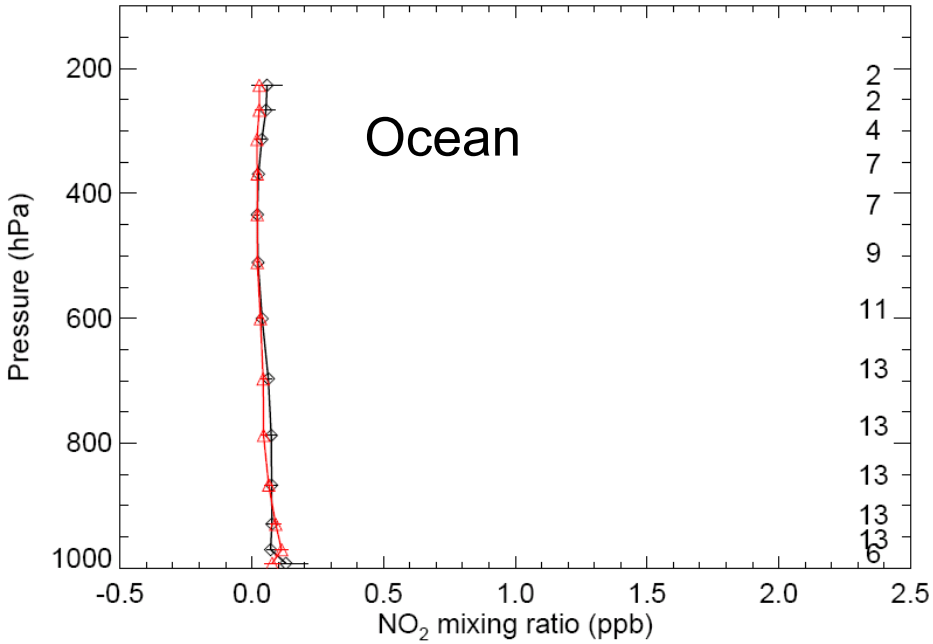
Width Gaussian = 0.59 molec. cm^{-2}



Mexico City

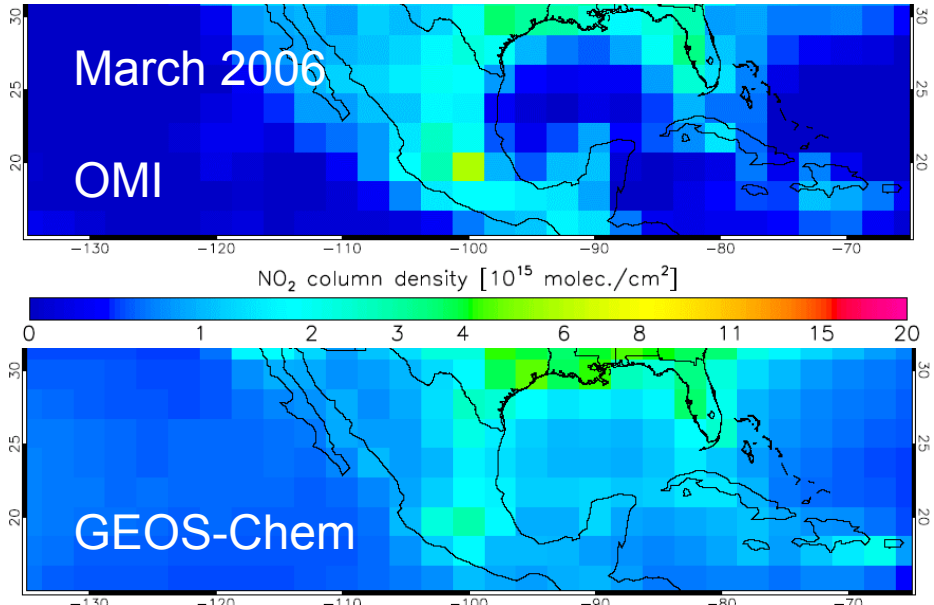
GEOS-Chem model evaluation with DC8





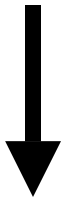
- GEOS-Chem OK over Gulf of Mexico
- OMI biased low over Gulf of Mexico relative to both DC8 and GEOS-Chem
- GEOS-Chem biased high over US in INTEX-B domain:

Are EPA NEI99 emissions too high?

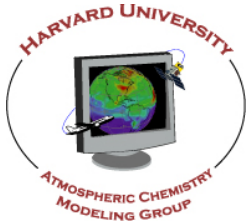


Validation: what do we see with INTEX-B?

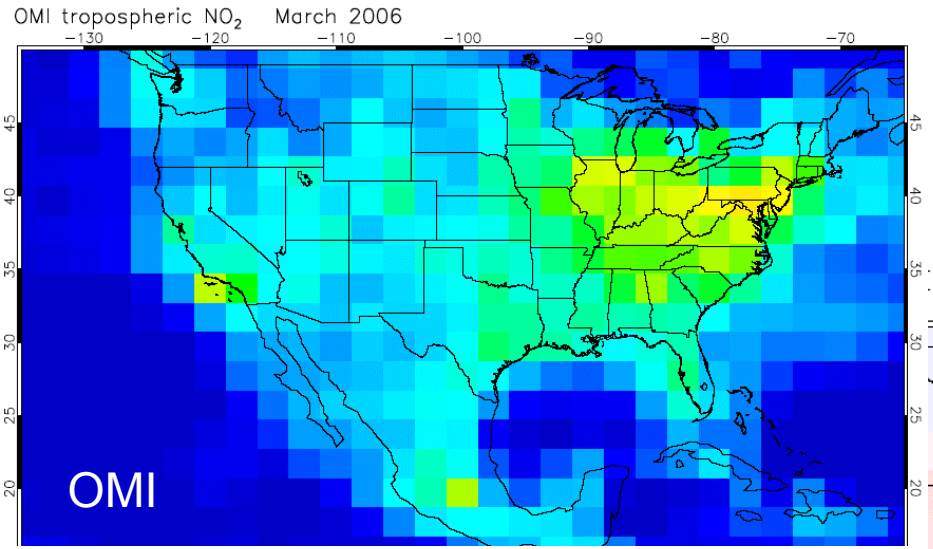
- OMI tropospheric NO_2 generally consistent with DC8 (r=0.89, n=18)
  - Bias < 0.2 10^{15} molec. cm^{-2}
  - Precision ~ 0.6 10^{15} molec. cm^{-2} (~50% in range 0-4 10^{15} molec. cm^{-2})
- OMI biased low over ocean
- Uncertainties in DC8 column construction over strongly polluted areas
- Indications that NEI99 emissions overestimate March 2006 emissions

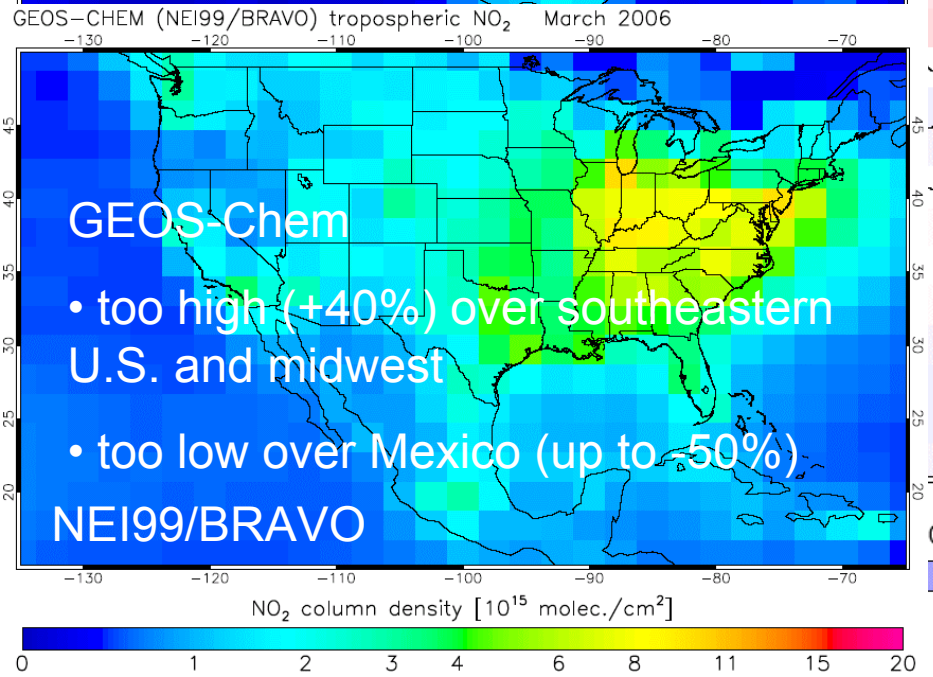


Use OMI and GEOS-Chem to evaluate EPA NEI99 emissions over the USA



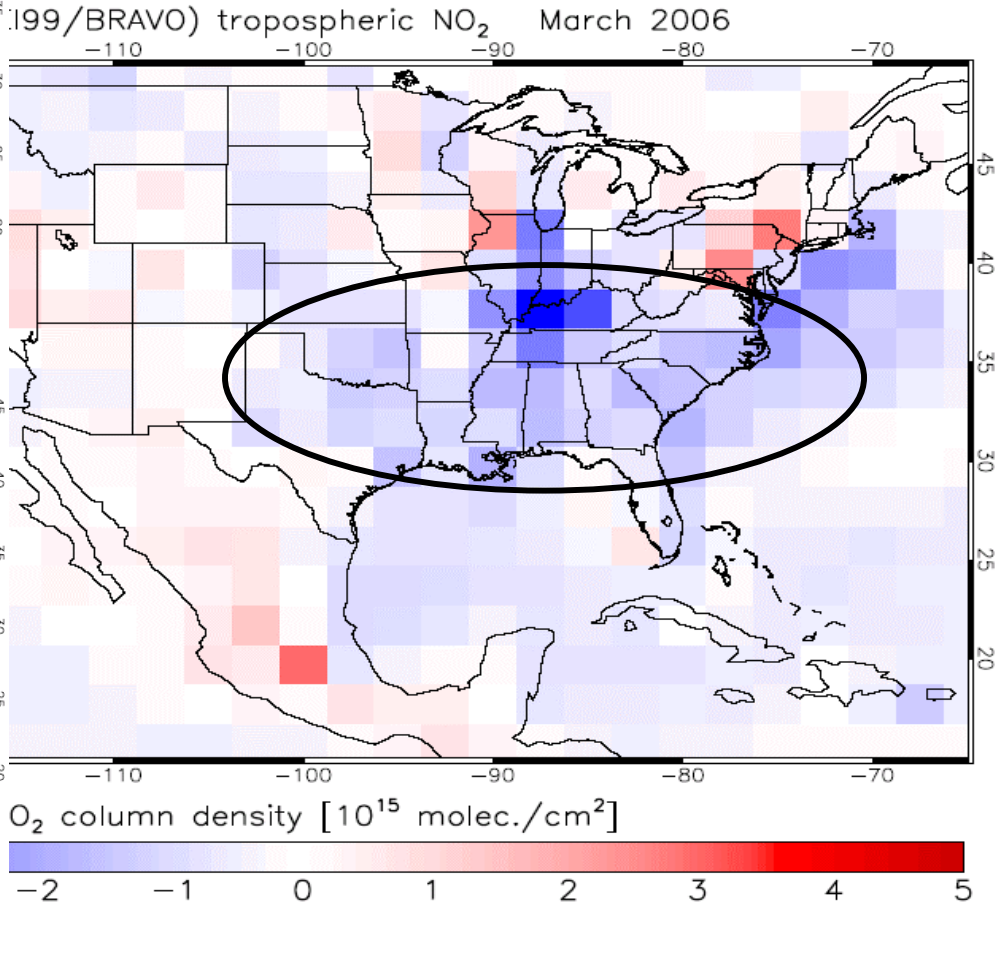
Compare monthly mean OMI and GEOS-Chem NO_2

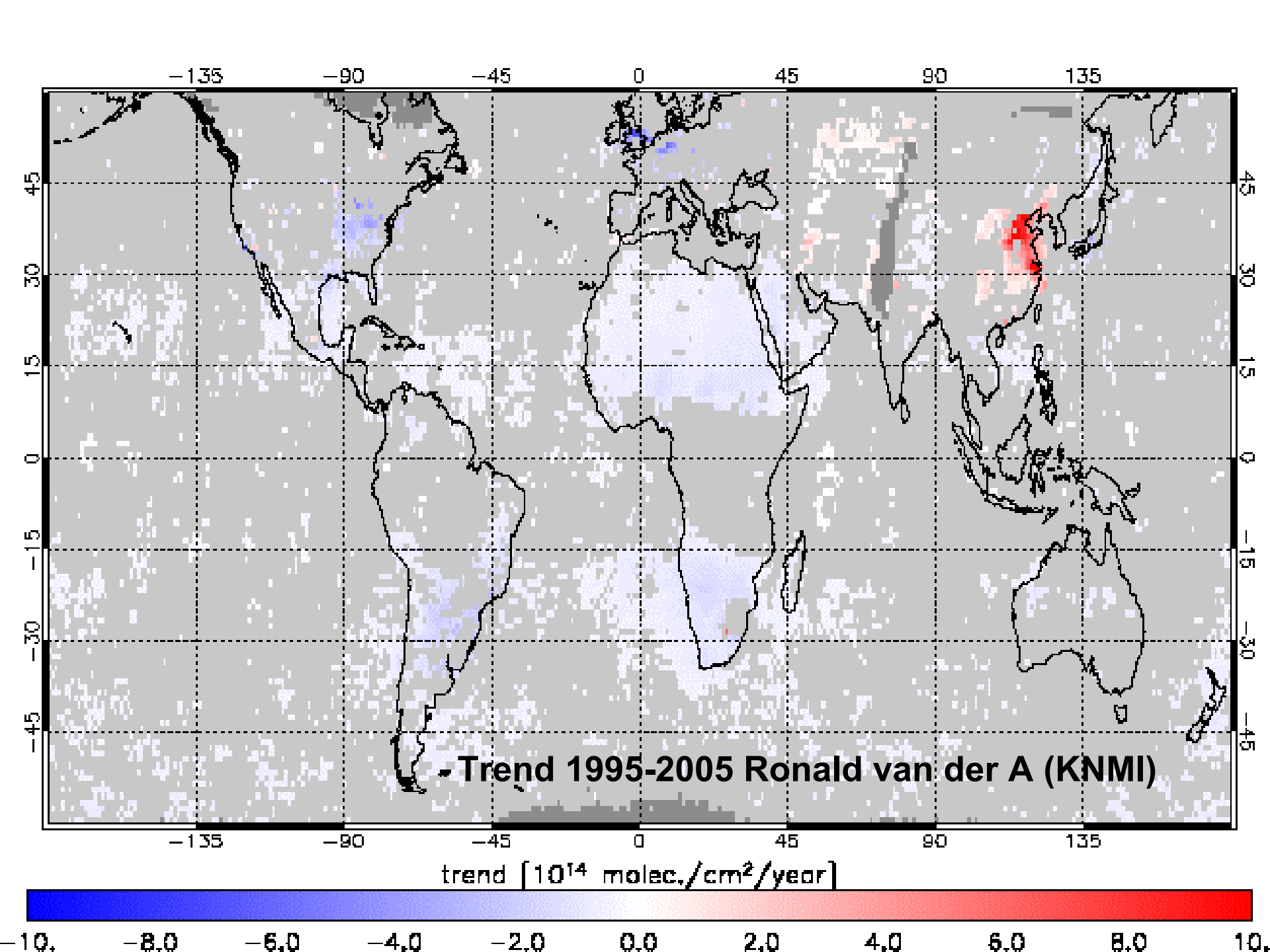




Overall pattern is captured

Take a more detailed look at the differences:

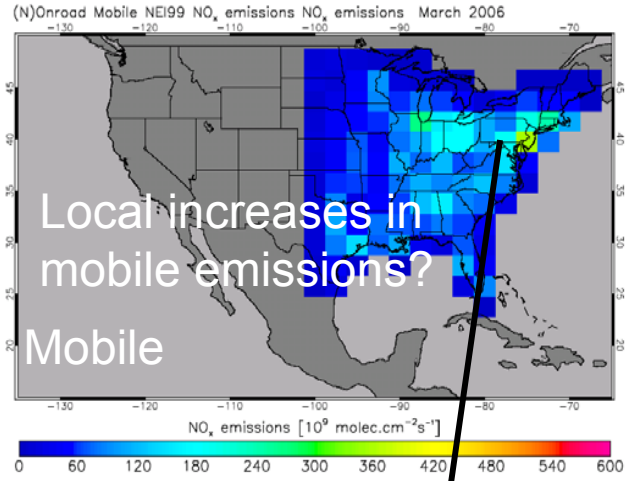



−135
−90
−45
0
45
90
135
45
30
15
0
−15
−30
−45
Trend 1995-2005 Ronald van der A (KNMI)
trend [10¹⁴ molec./cm²/year]
−10.
−8.0
−6.0
−4.0
−2.0
0.0
2.0
4.0
6.0
8.0
10.

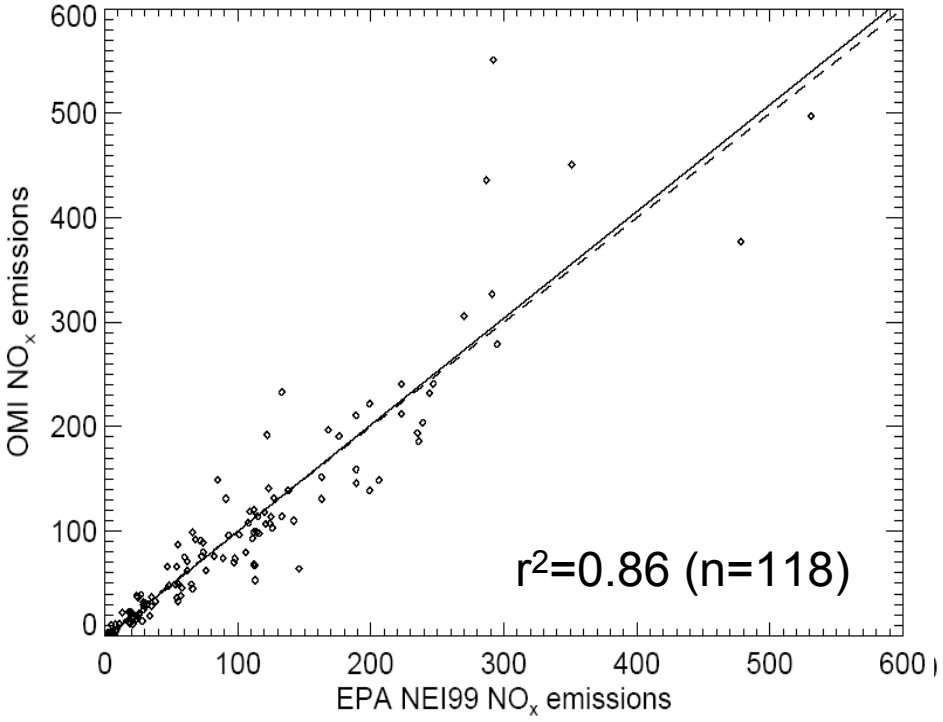
Improve EPA NEI99 emissions

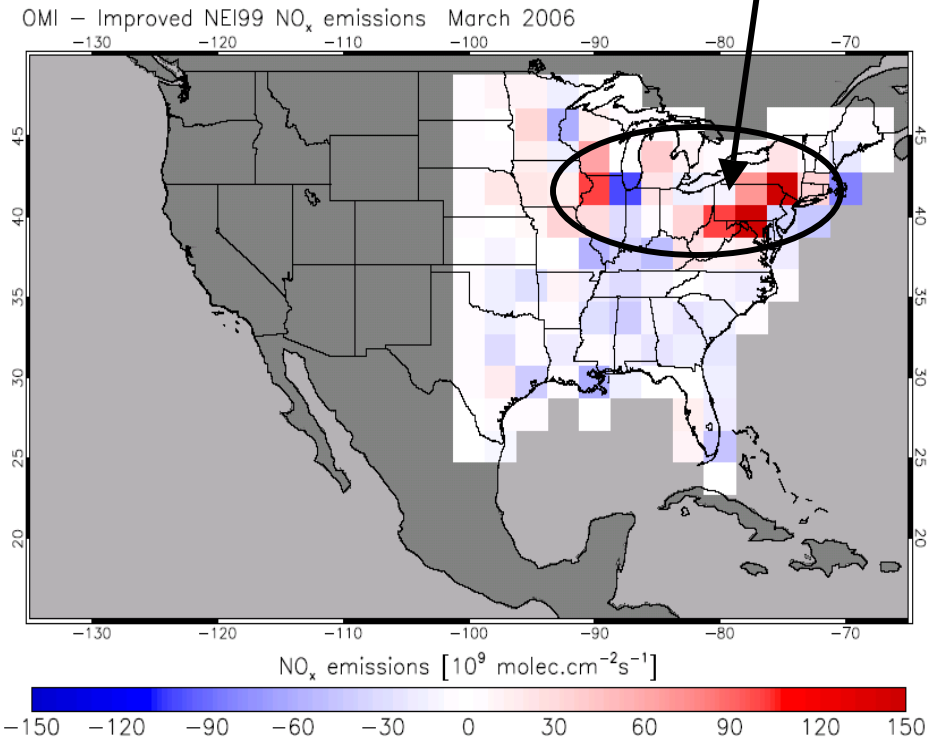
SVD-type method

- Industry: -40% (1999-2006)
- Power Industry: -40% consistent with NOx SIP
- (N)Onroad Mobile: 0%

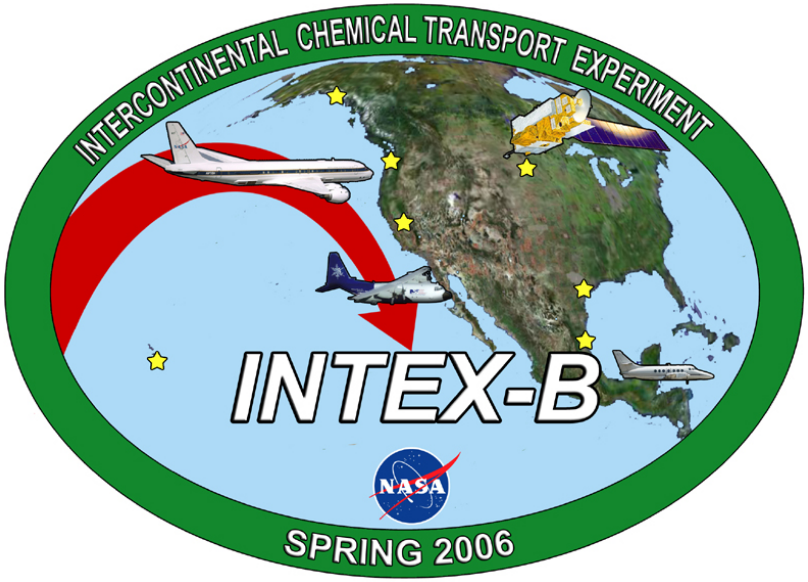


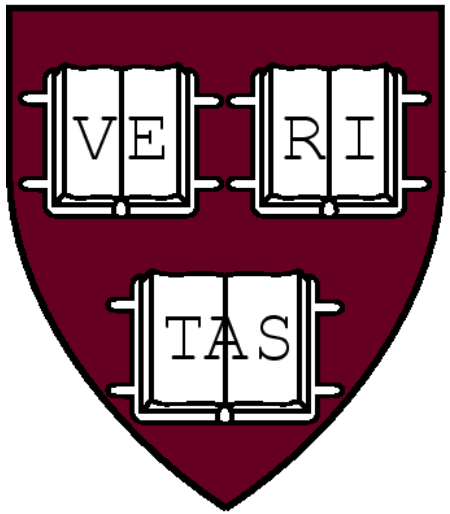
Compare top down and improved NEI99 emissions:

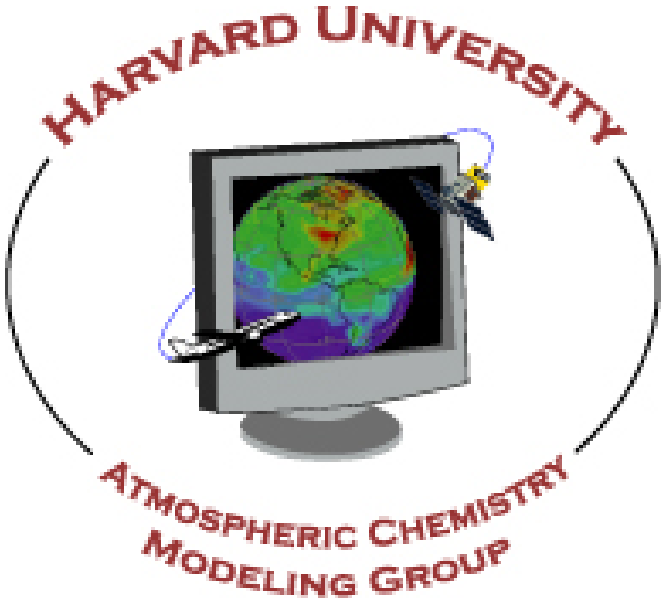




End of presentation

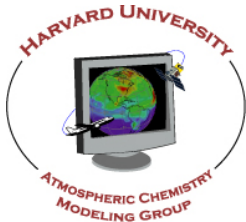


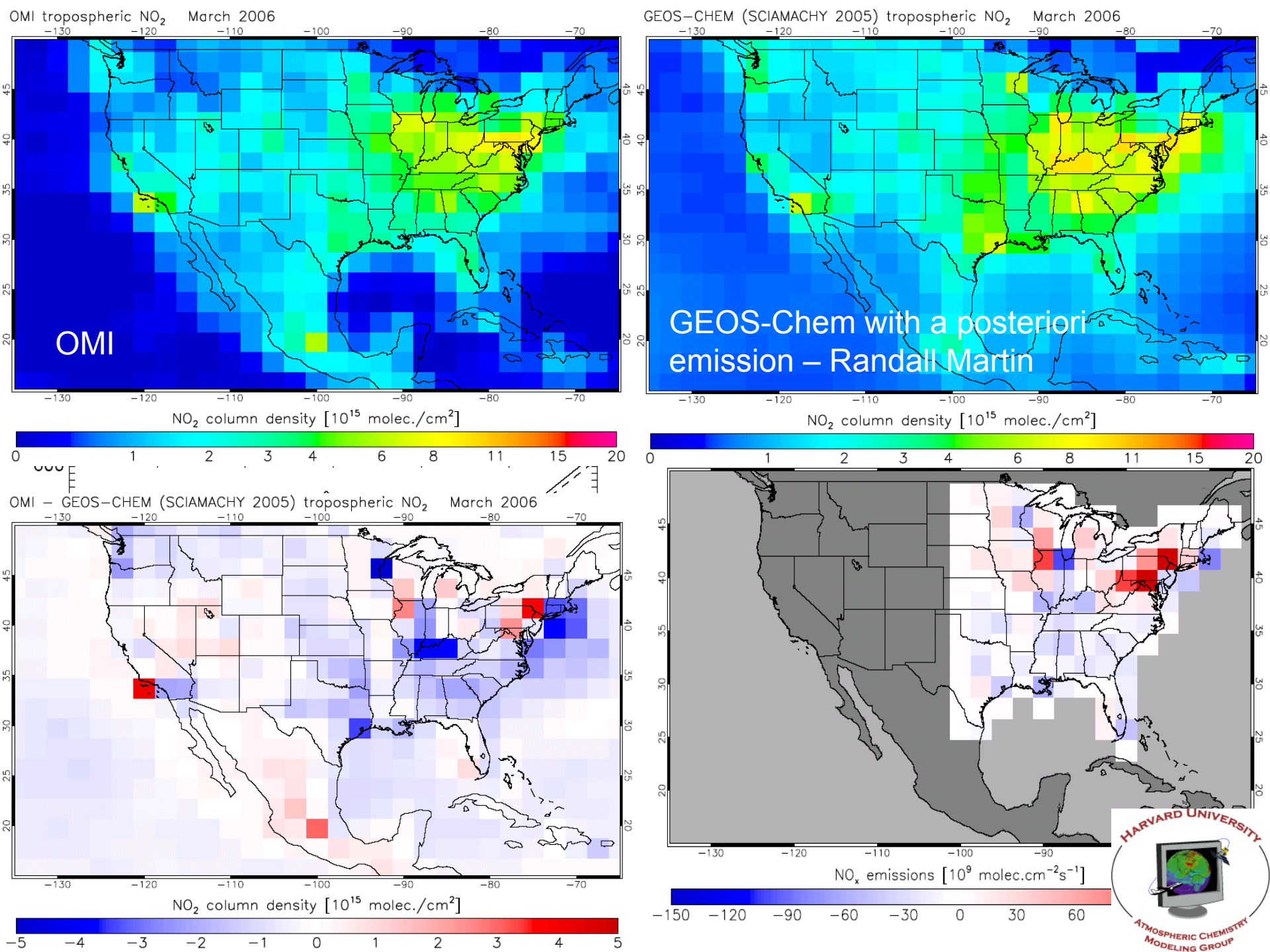




Conclusions

- INTEX-B allows integration of aircraft, satellite and model data
- OMI NO_2 is generally consistent with DC8 NO_2
- OMI NO_2 has a small, negative bias over the ocean (~0.5 10^{15} molec. cm^{-2})
- Indications from DC8 and OMI that EPA NEI99 emissions are too high in the eastern US
- 40% decrease in Industry and Power Plant NO_x emissions removes model bias in eastern and south eastern US




OMI tropospheric NO2 March 2006
OMI
GEOS-CHEM (SCIAMACHY 2005) tropospheric NO2 March 2006
GEOS-Chem with a posteriori emission – Randall Martin
NO2 column density [10^15 molec./cm^2]
0 1 2 3 4 6 8 11 15 20
OMI – GEOS-CHEM (SCIAMACHY 2005) tropospheric NO2 March 2006
NO2 column density [10^15 molec./cm^2]
−5 −4 −3 −2 −1 0 1 2 3 4 5
NOx emissions [10^9 molec.cm^−2s^−1]
−150 −120 −90 −60 −30 0 30 60
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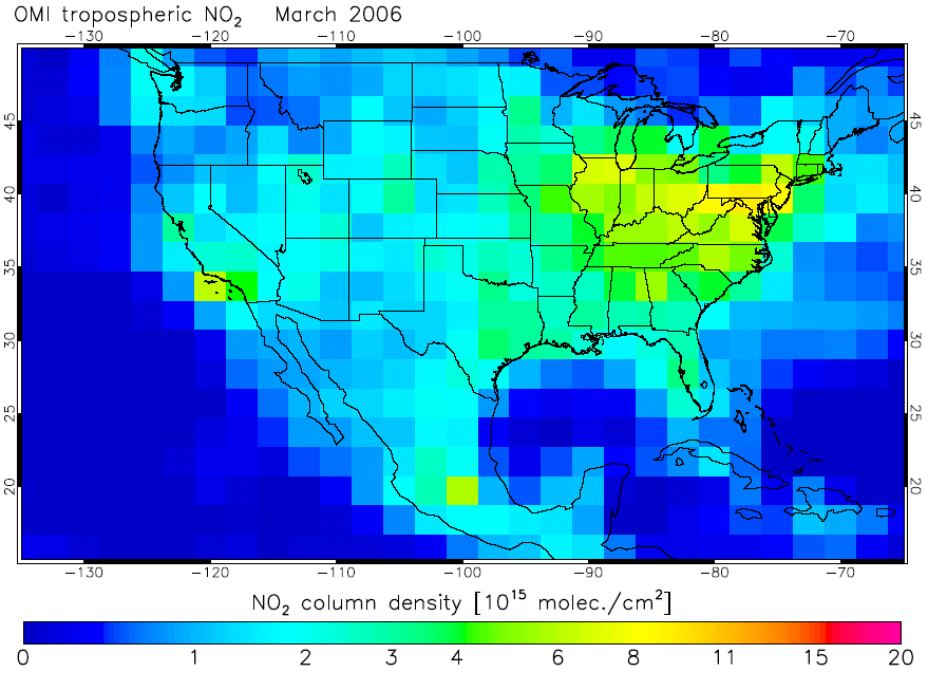
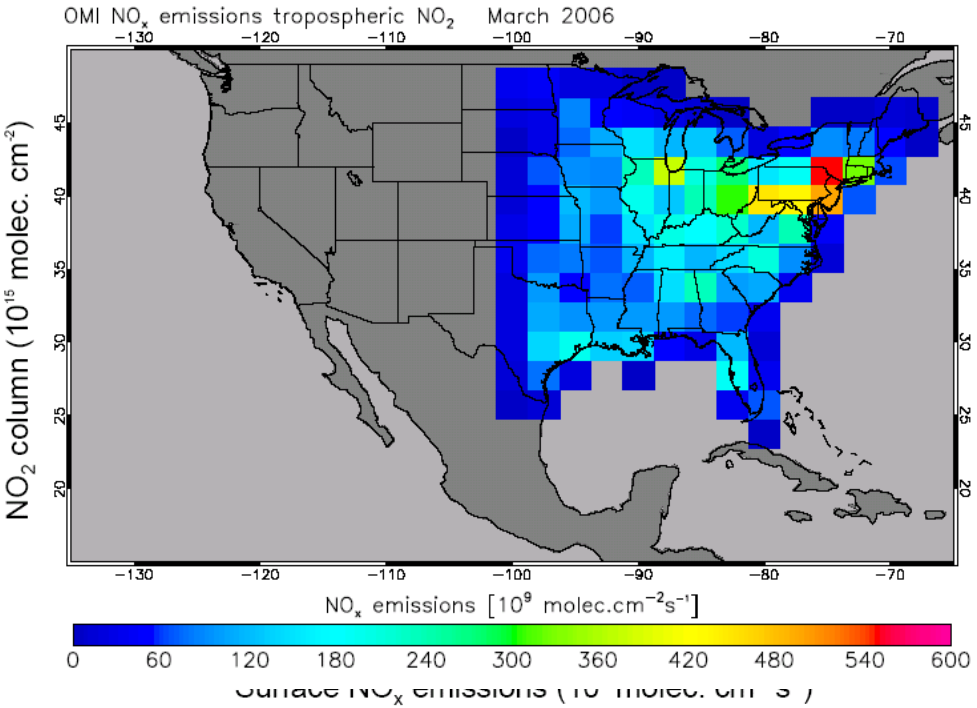
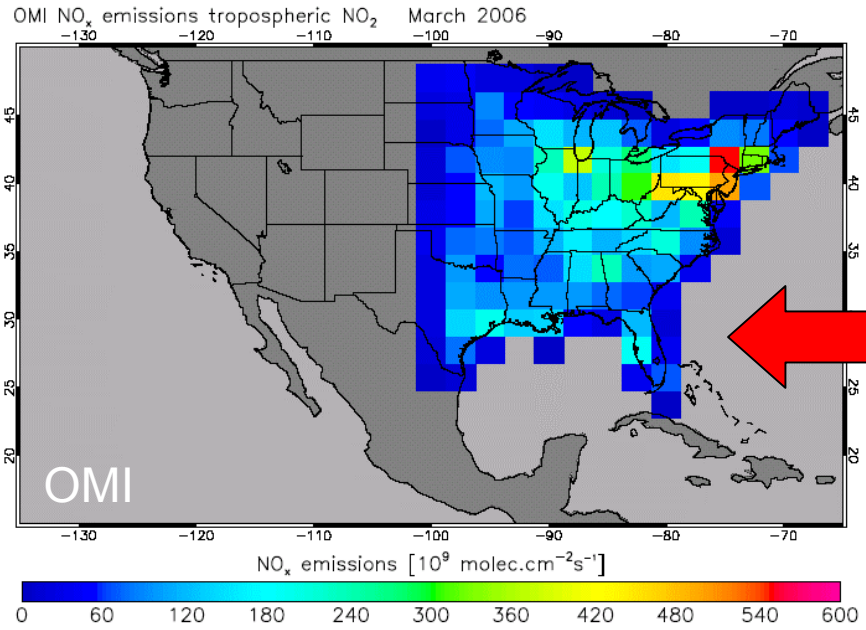
Compare Top-down and a priori emissions

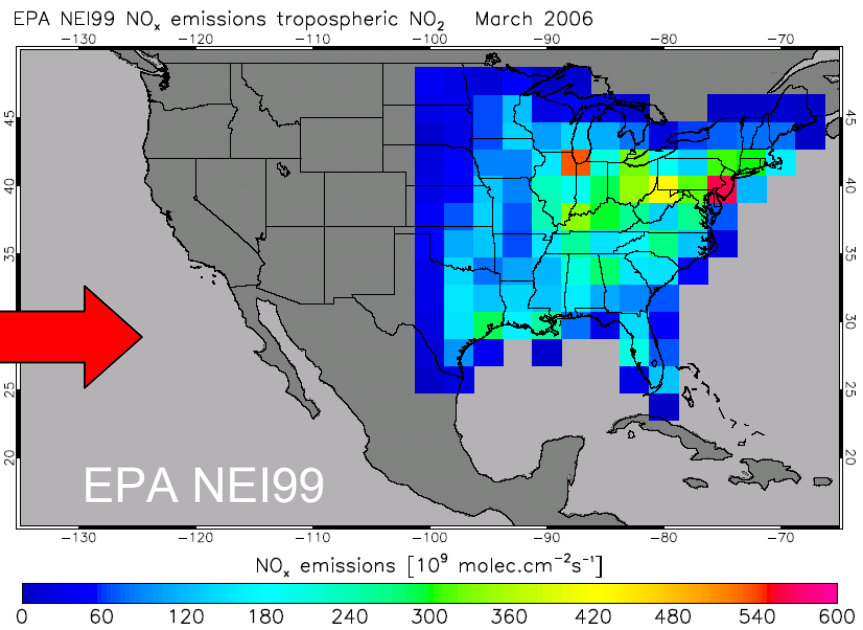
Use OMI columns and modelled emission respons to compute OMI top-down emissions – Focus on eastern US

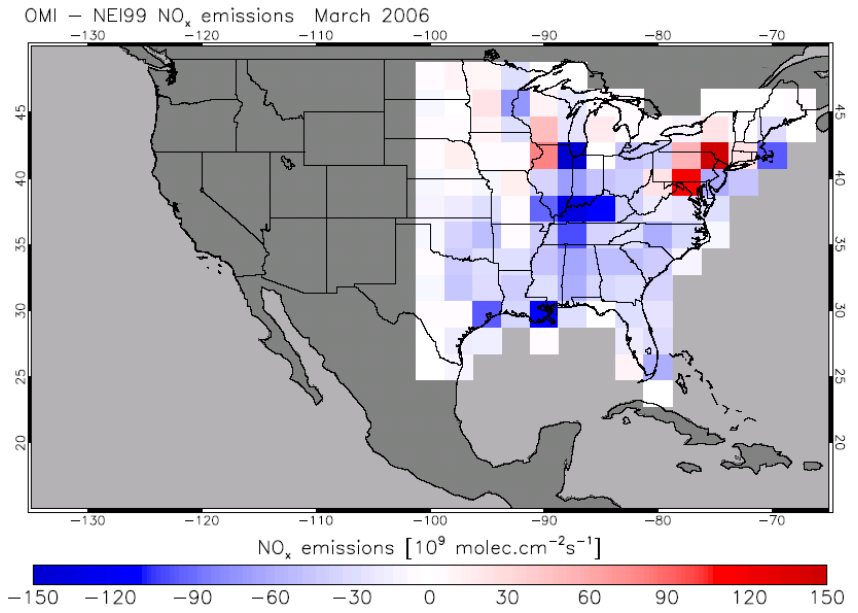


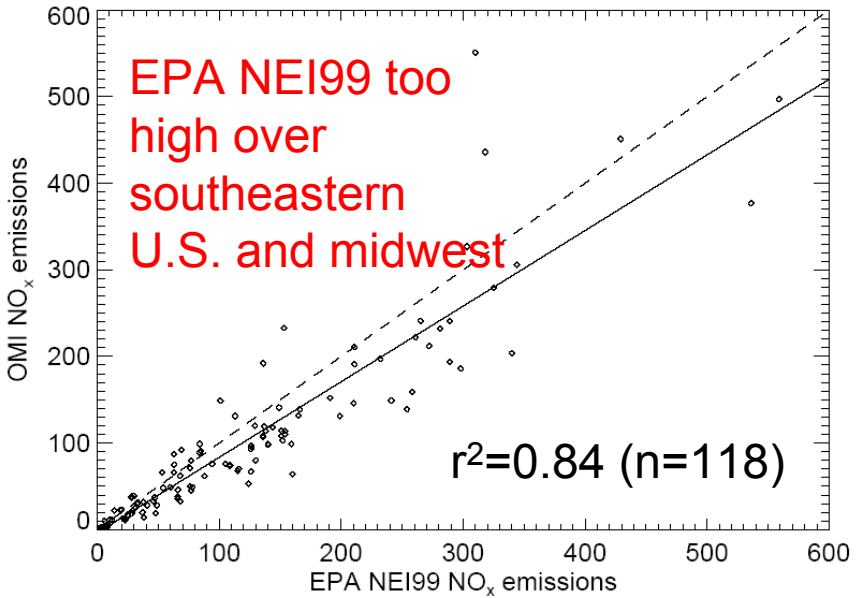


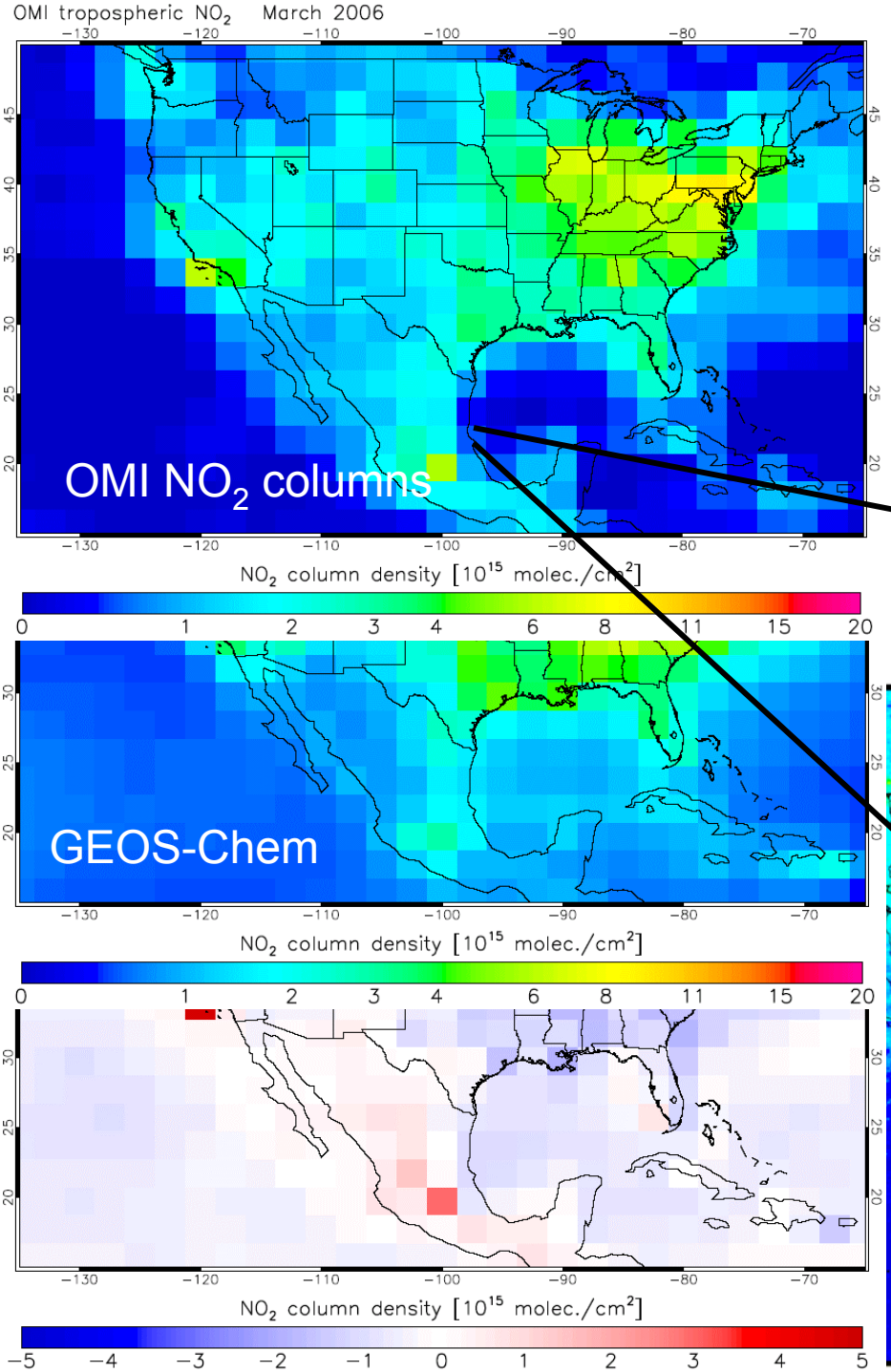
Compare top-down and EPA NEI99 emissions

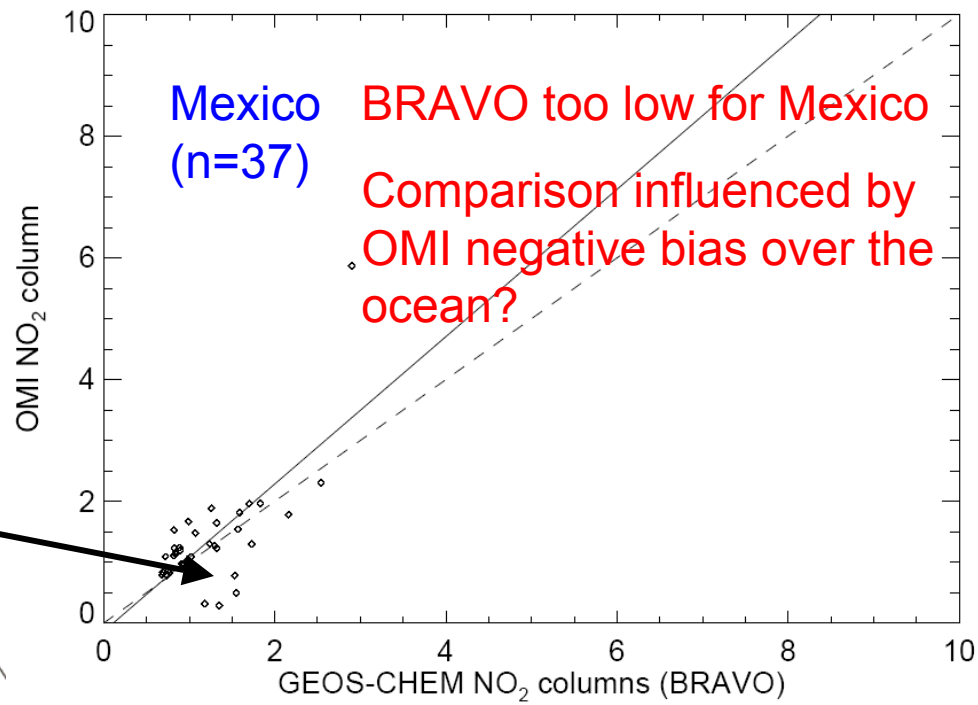


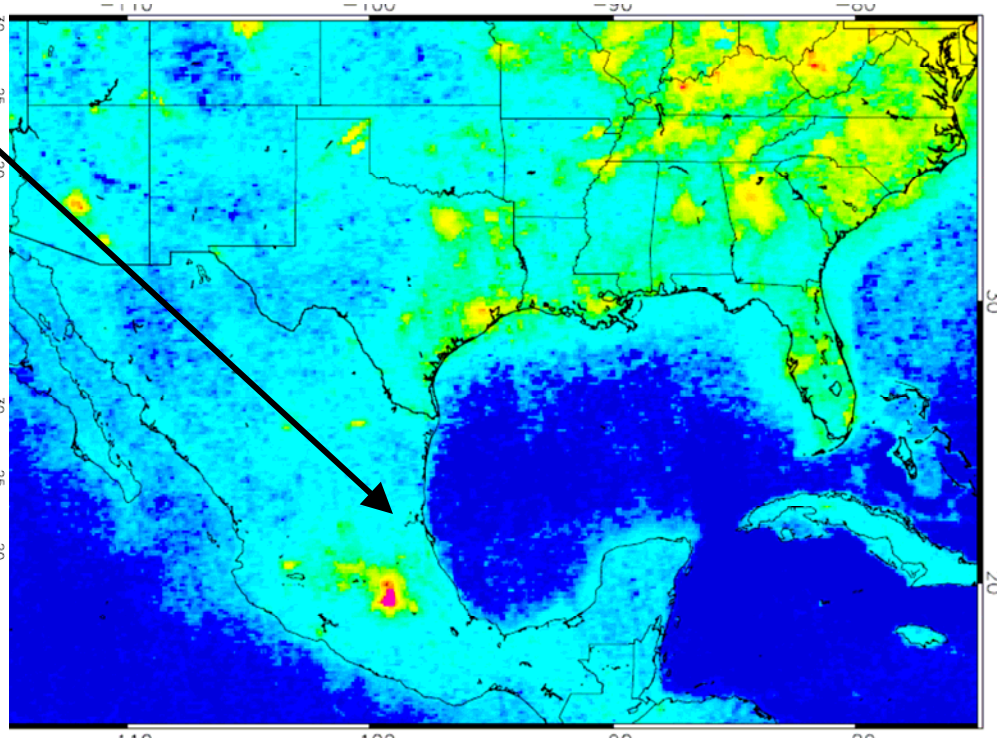




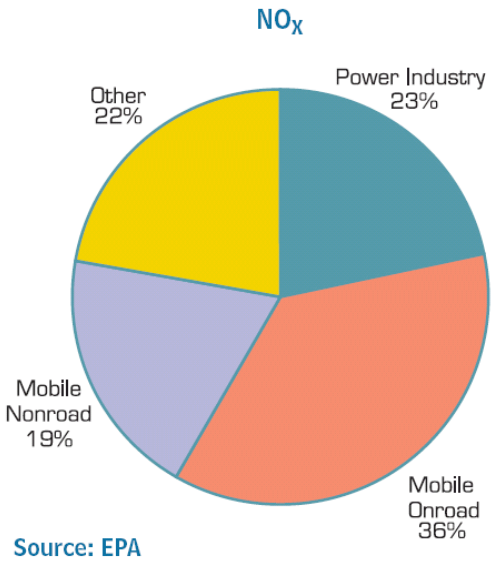


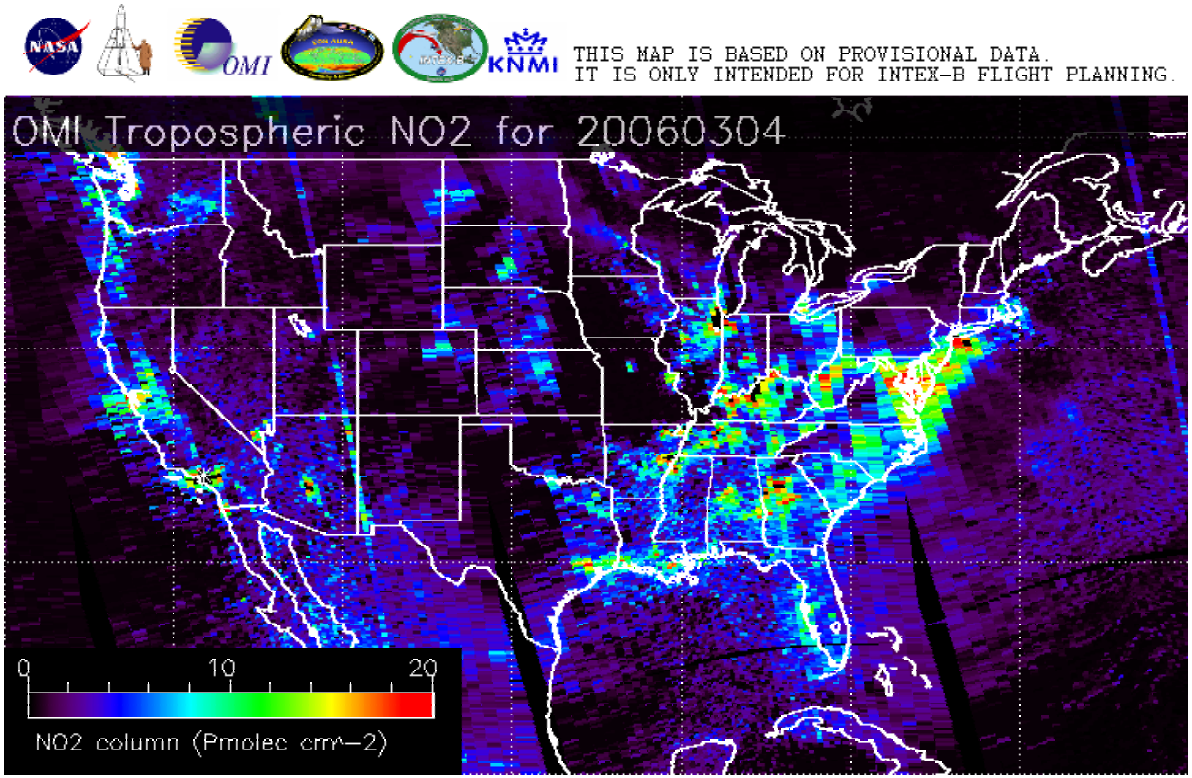

OMI tropospheric NO2 March 2006
OMI NO2 columns
NO2 column density [10^15 molec./cm^2]
0 1 2 3 4 6 8 11 15 20
GEOS-Chem
NO2 column density [10^15 molec./cm^2]
0 1 2 3 4 6 8 11 15 20
NO2 column density [10^15 molec./cm^2]
−5 −4 −3 −2 −1 0 1 2 3 4 5


Mexico
(n=37)
BRAVO too low for Mexico
Comparison influenced by OMI negative bias over the ocean?
OMI NO2 column
GEOS-CHEM NO2 columns (BRAVO)



Verdeling emissies





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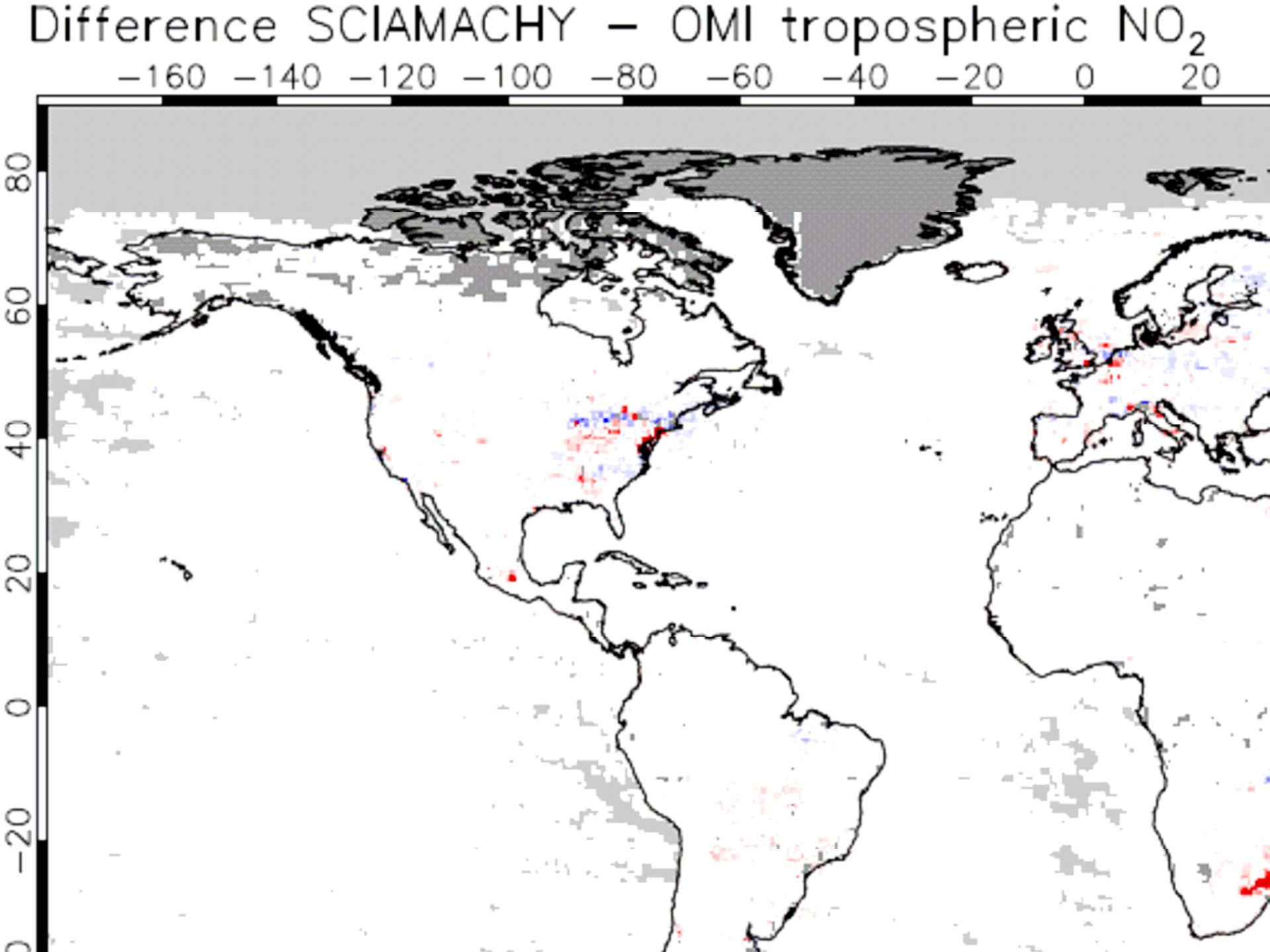
Difference SCIAMACHY – OMI tropospheric NO_2
−160 −140 −120 −100 −80 −60 −40 −20 0 20
80 60 40 20 0 −20